Potential Air Leakage Calculations

The MAC Equipment, Inc. Auto-Crusher Ventilation System is designed for 100-percent recirculation of air. In practical operation, however, some leakage may occur due to ambient environmental conditions, internal differential pressure and unpredictable variable rate of flow into the Z-Box classifier. Following are three potential areas identified that may leak air and dust:

1. Displaced Air

Two separate material streams are constantly moving through the system generated by the introduction of shredded material into the re-circulating air system, which after it is classified (separated), leaves the system at the Z-Box discharge (vibratory table) and the cyclone receiver discharge (rotary airlock), Due to variable and unpredictable inflow of material, the system will variously be "starved" and "flooded" with material, which may create a potential displacement (leakage) of dust-containing air as the system strives to regulate itself.

Shredded material is separated in the Z-Box by creating two distinct material streams moving through the system in opposite directions, at two different mass flows. Based on a 170 ton/hour (t/hr) mass flow of mixed material fed into the Z-Box, the following streams are generated:

A. Shredded ferrous material at 85 pounds per cubic foot (lbs/cf) at a rate of 238,000 pounds per hour (lbs/hr) passes through the Z-Box. Evaluating air displacement on a per-minute basis:

$$\frac{238{,}000 \text{ lbs/hr}}{85 \text{ lbs/cf}} = \frac{2{,}800 \text{ cf/hr}}{60 \text{ min/hr}} = \mathbf{46.67 \text{ cfm}}$$

B. Automobile shredder residue (ASR) at 35 lbs/cf at a rate of 102,000 lbs/hr is separated in the Z-Box and is transferred to the cyclone via duct work. Evaluating air displacement on a per-minute basis:

$$\frac{102{,}000 \text{ /bs/hr}}{35 \text{ lbs/cf}} = \frac{2{,}914 \text{ cf/hr}}{60 \text{ min/hr}} = \mathbf{48.57 \text{ cfm}}$$

2. Differential Pressure Effect at Airlock

Air at ambient conditions will be introduced into the system via empty returning pockets at the airlock. Due to the differential pressure, the air will likely expand in the cyclone. The expansion of air will displace system air by applying the Ideal Gas Law:

Ideal Gas Law: $PV = mRT$ where: P = pressure (PSIA)
V = volume (cf)
M = mass (lb)
R = Regnault constant (53.35 [ft-lb_f]/[lb_m/^oR])
T = absolute temperature (^oF)

$$m = PV/RT \Rightarrow \Delta m = \Delta PV/RT \Rightarrow \overline{m} = \Delta m/t \Rightarrow Q = \overline{m}/\rho = \Delta PV/RT t \rho$$

where: Q = air flow (cf/min)
$\overline{m}$ = mass flow (lb/min)
t = time (min)
ρ = density (lbs/cf)

The airlock is a FS48x48 with 24 rpm, pressure at 8" (H_2O), temperature at 70^o F, 14.696 PSIA and 47.5 cf of air space:

$$Q = \frac{(14.696 - (14.696 - (8/27.7)))*(144\ in^2/ft^2)*(47.5)*(24)}{(53.35)*(70 + 460)*(1\ min.)*(0.0749)} = \mathbf{22.38\ cfm}$$

Total Potential Air Displacement:

- Shredded metal displacement 46.67 cfm
- ASR displacement 48.57 cfm
- Airlock Displacement 22.38 cfm

117.62 cfm

Air leakage will carry a dust load equivalent to that of the recirculating system:

$$174\ lbs/hr * 1\ hr/60\ min = \frac{2.9\ lbs/min}{6{,}000\ cfm} = 0.000483\ lbs/cf$$

$117.62\ cf/min * 0.000483\ lbs/cf = \mathbf{0.057\ lbs/min}$

Or

$0.057\ lbs/min * 60\ min/hr = (3.42\ lb/hr)/(170\ ton/hr) = \mathbf{0.020\ lb/ton}$